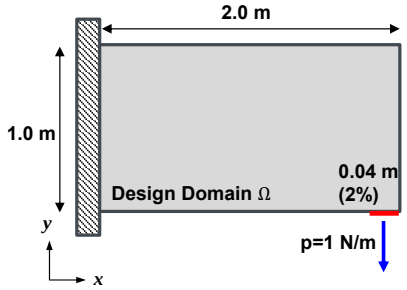
Topology Optimization
Using Neural Networks Only

Systematic Structure Design Lab.
School of Mechanical Engineering,
Yonsei University, Korea

Design Problem



- The fixed design domain Ω has a size with an aspect ratio of 2
- The left side of Ω is fixed in the x- and y-directions.
- The force of magnitude 1 N/m is loaded downward on the bottom right part of 2% of the design domain width.
- The number of collocation points in the model is 200×100.

$$\min_{\rho} \quad J(\rho, \mathbf{u}(\rho)) := \int_{\Gamma_N} \mathbf{u} \cdot \mathbf{f}\, dl$$

$$\text{s.t.} \quad \begin{cases} -\nabla \cdot [\mathbf{C}(\rho)\boldsymbol{\varepsilon}(\mathbf{u})] = 0 & \text{in } \Omega \\ \mathbf{u} = \bar{\mathbf{u}} & \text{on } \Gamma_D, \\ \mathbf{n} \cdot \boldsymbol{\sigma} = \mathbf{f} & \text{on } \Gamma_N \end{cases}$$

$$G(\rho) := \frac{\int_\Omega \rho\, dA}{|\Omega|} - V_{req} \le 0,$$

$$0 \le \rho(\mathbf{x}) \le 1, \quad \mathbf{x} \in \Omega.$$

Optimization Problem

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s.t.
$$\begin{cases} -\nabla \cdot [\mathbf{C}(\rho)\boldsymbol{\varepsilon}(\mathbf{u})] = 0 & \text{in } \Omega \\ \mathbf{u} = \bar{\mathbf{u}} & \text{on } \Gamma_D, \\ \mathbf{n} \cdot \boldsymbol{\sigma} = \mathbf{f} & \text{on } \Gamma_N \end{cases}$$

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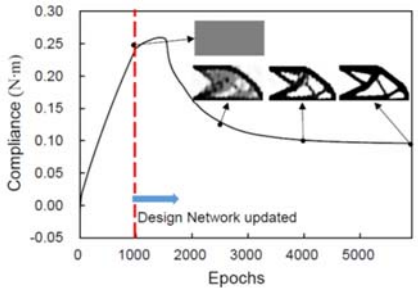
$$0 \le \rho(\mathbf{x}) \le 1, \quad \mathbf{x} \in \Omega.$$

The objective function $J(\rho, \mathbf{u}(\rho))$ is defined as 'compliance', a virtual work produced by external forces $\mathbf{f}$. The state variable $\mathbf{u}$ is a displacement vector that is an implicit function of the design variable ρ. The system satisfies the constitutive equations of a linear elastic solid in the bounded domain $\Omega \subset \mathbb{R}^d (d = 2 \text{ or } 3)$. The boundary $\partial\Omega$ of the domain is divided into two parts: One is the Dirichlet boundary Γ_D and the other is the Neumann boundary $\Gamma_N = \partial\Omega \setminus \Gamma_D$. $\bar{\mathbf{u}}$ is a prescribed displacement vector on Γ_D and $\mathbf{f}$ is a traction force vector applied to Γ_N. $\mathbf{n}$ is the normal vector on boundaries pointing outward from the domain. $\mathbf{C}(\rho)$ is the fourth order elasticity tensor, which is a function of the design variable itself and has information between the Cauchy stress tensor $\boldsymbol{\sigma}$ and the infinitesimal strain tensor $\boldsymbol{\varepsilon}(\mathbf{u}) = \left(\nabla\mathbf{u} + (\nabla\mathbf{u})^T\right)/2$ as $\boldsymbol{\sigma} = \mathbf{C}(\rho)\boldsymbol{\varepsilon}(\mathbf{u})$. The volume constraint function $G(\rho)$ must be smaller than 0 where $|\Omega|$ is the area of the given domain Ω with the desired volume fraction V_{req}.

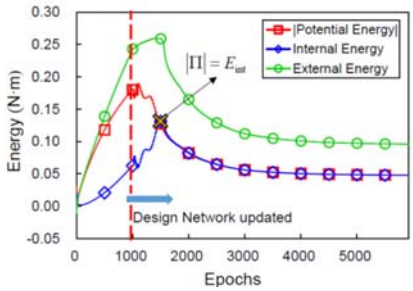
Design Results & Convergence History Plots



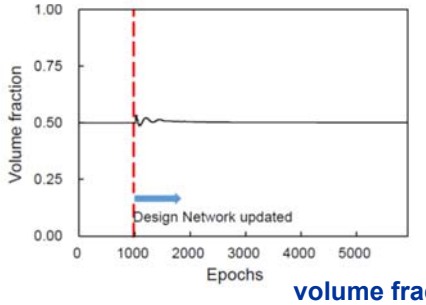
Obtained result



compliance



energy



volume fraction